

# New Plutonium Isotope, $^{231}\text{Pu}$

C.A. Laue, K.E. Gregorich, R. Sudowe, M.B. Hendricks, J.L. Adams, M.R. Lane, D.M. Lee, C.A. McGrath, D.A. Shaughnessy, D.A. Strellis, E.R. Sylwester, P.A. Wilk, and D.C. Hoffman

Research on the production and identification of new neutron-deficient actinides is of continuing interest. Information gained by identifying new isotopes, their decay properties, and measuring excitation functions for their production adds substantially to our knowledge of the systematics of nuclear stability and production reaction mechanisms. In the early '90s, a Russian team identified the plutonium isotopes with mass numbers 228, 229 and 230 [1], leaving a blank spot in the Chart of the Nuclides between the isotopes  $^{230}\text{Pu}$  and  $^{232}\text{Pu}$ .

During the last few years, the  $^{233}\text{U} (^3\text{He}, \text{xn})$  reaction was intensively explored. The cross section for the 5n-product,  $^{231}\text{Pu}$ , was expected to be 20  $\mu\text{b}$  [2]. The expected half-life of  $^{231}\text{Pu}$  ranged from 3 to 30 min. In addition, to efficiently investigate the reaction products of the xn-channel, plutonium had to be separated from the other actinide reaction products within a very limited time frame. The chemical procedure developed is described in further detail in [3].

The new plutonium isotope,  $^{231}\text{Pu}$ , was produced by the  $^{233}\text{U} (^3\text{He}, 5\text{n}) ^{231}\text{Pu}$  reaction. A set of eleven  $^{233}\text{U}$  targets arranged in our LIM target system [4] was irradiated with a 48-MeV- $^3\text{He}^{2+}$  beam, produced by the 88-Inch Cyclotron. The beam intensity averaged 9  $\mu\text{A}$ . The recoiling reaction products were stopped in helium, attached to aerosols, and transported to the collection site by a helium-jet system. The collected aerosol samples, bearing the reaction products, were chemically processed as described in [3]. The purified plutonium samples were analyzed using  $\alpha$ -spectrometry. The isotope,  $^{231}\text{Pu}$ , was unequivocally identified by the  $\alpha$ -decay of the chain members from its  $\alpha$ - and electron-capture daughters using the  $\alpha$ - $\alpha$ -correlation technique, resulting in a half-life of  $(8.6 \pm 0.5)$  min. The figure shows the  $\alpha$ -decay chain from the  $^{231}\text{Pu}$   $\alpha$ -branch. Although the  $^{231}\text{Pu}$

$\alpha$ -branch is only  $\sim 10\%$ , it can be easily identified. The remaining 90% of the  $^{231}\text{Pu}$  decay is by electron capture. An  $\alpha$ -group with an energy of  $(6.720 \pm 0.030)$  MeV was assigned to  $^{231}\text{Pu}$ . Assuming that  $^{231}\text{Pu}$  decays to the  $^3/2^+$  [631] ground state in  $^{227}\text{U}$ , the  $Q_\alpha$ -value is  $6.838 \pm 0.030$  MeV and the mass excess is  $38.270 \pm 0.035$  MeV. The ground state of  $^{231}\text{Pu}$  is most likely  $^3/2^+$  [631]. [5]

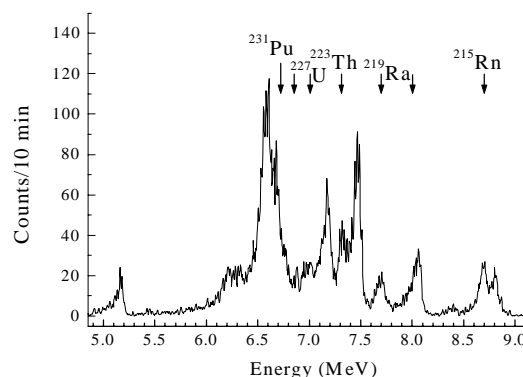


Fig: Summed  $\alpha$ -spectrum of purified plutonium samples, indicating members of the  $\alpha$ -decay chain of the  $^{231}\text{Pu}$   $\alpha$ -branch.

## Footnotes and References

- [1] A.N. Andreyev et al., Z.Phys. A **337**, 231 (1990), A.N. Andreyev et al., Z.Phys. A **347**, 225 (1994).
- [2] C.A. Laue et al., LBNL, 1997 Annual Report NSD, LBL **39764**, N27, 1998.
- [3] C. A. Laue et al., contribution to this report.
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